We claim:

1. In a computerized spreadsheet which includes multiple spreadsheet cells, a method for testing a first spreadsheet cell containing a first formula, the method comprising:

    creating a first formula graph for the first formula of the first spreadsheet cell, the first

5   formula graph containing nodes representing predicates and definitions in the first formula of the first spreadsheet cell and edges representing execution flow between the nodes of the first formula graph;

    collecting one or more du-associations for the first spreadsheet cell, where each du-association relates a node in a second formula graph for a second formula of a second

10 spreadsheet cell with one of a node or edge in the first formula graph of the first spreadsheet cell;

    tracking an execution trace for the first spreadsheet cell, where the execution trace comprises a sequence of nodes in the first formula graph of the first spreadsheet cell and a set of edges from the first formula graph connecting pairs of the nodes in the execution trace

15 sequence; and

    after receiving a user validation of the first spreadsheet cell, marking as exercised the du-associations containing a node or edge in the execution trace for the first spreadsheet cell.

2. A method according to claim 1 further comprising repeating the steps of

20 creating, collecting, tracking, and marking for each second spreadsheet cell with an exercised du-association so that any du-associations for each second spreadsheet cell are marked as exercised after at least one of the first spreadsheet cell and second spreadsheet cell has been user-validated.

25 3. In a computerized spreadsheet containing a plurality of spreadsheet cells, a method for testing a first spreadsheet cell containing a formula, the method comprising:

    collecting one or more test elements for the first spreadsheet cell;

    tracking an execution trace of the first spreadsheet cell; and

    marking as exercised a subset of the test elements that participated in the execution

30 trace for the first spreadsheet cell.

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4.   A method according to claim 3 further comprising:

identifying all other spreadsheet cells upon which the first spreadsheet cell depends; and

for each other spreadsheet cell, repeating the steps of collecting, tracking, and

5   marking.

5.   A method according to claim 3 wherein collecting one or more test elements includes collecting one or more du-associations for the first spreadsheet cell.

10   6.   A method according to claim 5 wherein one or more du-associations are collected as the formula is entered into the first spreadsheet cell.

7.   A method according to claim 5 wherein collecting one or more du-associations includes:

15   identifying all other cells used in the formula of the first spreadsheet cell;

identifying all definitions of the other cells that are used in the formula of the first spreadsheet cell; and

creating a du-association between each definition of the other cells and each use of the definition in the formula of the first spreadsheet cell.

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8.   A method according to claim 3 wherein tracking an execution trace includes tracking which parts of the formula for the first spreadsheet cell have been exercised.

9.   A method according to claim 8 wherein marking as exercised a subset of the

25   test elements includes marking du-associations for the first spreadsheet cell that were exercised by the execution trace for the first spreadsheet cell, where each du-association includes a definition of a second cell and a use of the definition of the second cell in the formula for the first spreadsheet cell.

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10. A method according to claim 9 wherein marking du-associations includes marking as exercised each du-association whose use is part of the formula for the first spreadsheet cell that has been executed.

5   11. A method according to claim 3 wherein marking as exercised a subset of the test elements includes:

receiving a user validation of the first spreadsheet cell; and

after receiving the user validation of the first spreadsheet cell, marking as exercised the subset of test elements that participated in the execution trace for the first spreadsheet

10   cell.

12. A method according to claim 11 further comprising:

identifying all other spreadsheet cells upon which the first spreadsheet cell depends; and

15   for each other spreadsheet cell, repeating the steps of collecting, tracking, and marking so that any test elements for each other spreadsheet cell are marked as exercised independently of whether each other spreadsheet cell has been user-validated.

13. A method according to claim 11 wherein receiving a user validation includes

20   having a user click on a validation tab for the first spreadsheet cell.

14. A method according to claim 11 wherein receiving a user validation includes:

storing a validation symbol for the first spreadsheet cell; and

displaying the validation symbol for the first spreadsheet cell.

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15. A method according to claim 14 wherein displaying the validation symbol includes displaying the validation symbol for the first spreadsheet cell in a validation tab.

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16. A method according to claim 3 further comprising:

discarding the test elements for the first spreadsheet cell after a user changes the formula for the first spreadsheet cell; and

repeating the steps of collecting, tracking, and marking for the first spreadsheet cell.

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17. A method according to claim 16 wherein discarding the test elements for the first spreadsheet cell includes:

identifying all other cells in the spreadsheet that depend on the first spreadsheet cell; and

10 marking as unexercised all test elements for the identified cells that use a definition of the first spreadsheet cell.

18. A method according to claim 17 wherein marking as unexercised all test elements for the identified cells includes invalidating a user validation for the identified cells.

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19. A method according to claim 18 wherein invalidating a user validation includes changing a validation symbol representing a validated spreadsheet cell for the identified cells to a validation symbol representing uncertainty for the identified cells.

20. A method according to claim 19 wherein invalidating a user validation includes displaying the validation symbol representing uncertainty for the identified cells.

21. A method according to claim 20 wherein displaying the changed validation symbol includes displaying the validation symbol representing uncertainty for the identified
25 cells in a validation tab.

22. A method according to claim 19 wherein:
the validation symbol representing a validated spreadsheet cell is a checkmark; and
the validation symbol representing uncertainty is a question mark.

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23. A method according to claim 18 wherein invalidating a user validation includes removing a validation symbol representing a validated spreadsheet cell for the identified cells.

5   24. A method according to claim 16 wherein discarding the test elements for the first spreadsheet cell includes invalidating a user validation for the first spreadsheet cell.

25. A method according to claim 24 wherein invalidating a user validation includes removing a validation symbol representing a validated spreadsheet cell for the first

10   spreadsheet cell.

26. A method according to claim 25 wherein:
the validation symbol representing a validated spreadsheet cell is a checkmark.

15   27. A method according to claim 3 further comprising marking as unexercised a subset of the test elements for the first spreadsheet cell that are affected by a change in the formula for the first spreadsheet cell.

28. A method according to claim 3 further comprising providing the user with an

20   indication of whether the first spreadsheet cell has been completely tested.

29. A method according to claim 3 further comprising providing the user with an indication of how completely the first spreadsheet cell has been tested.

25   30. A method according to claim 3 wherein the test elements are chosen from the group consisting of du-associations, node identifications, edge identifications, and cell identifications.

31. A method according to claim 3 further comprising selecting the first

30   spreadsheet cell from the plurality of spreadsheet cells.

32.   In a computerized spreadsheet containing a plurality of spreadsheet cells, a method for batch-collecting one or more test elements for a group of spreadsheet cells containing formulae to facilitate testing a first spreadsheet cell, the method comprising:

identifying all the spreadsheet cells upon which the group depends; and

collecting one or more test elements for each spreadsheet cell that depends upon an identified cell or the group of spreadsheet cells.

33.   In a computerized spreadsheet, a method for providing a user with an indication of how completely tested a spreadsheet cell is, the method comprising:

maintaining a set of test elements for the spreadsheet cell;

identifying a subset of the set of test elements that have been exercised;

using the set of test elements and the subset of the set, calculating a testedness measure of test elements that have been exercised; and

providing the user with an indication of the testedness measure.

34.   A method according to claim 33 wherein providing the user with an indication of the testedness measure includes providing the user with visual feedback of the testedness measure.

35.   A method according to claim 34 wherein providing the user with visual feedback includes coloring a border of the spreadsheet cell, where the color chosen indicates the testedness measure.

36.   A method according to claim 35 wherein the color chosen to indicate the testedness measure varies between red and blue, the color red representing a 0% testedness percentage and the color blue representing a 100% testedness percentage.

37.   A method according to claim 33 further including updating the indication of the testedness measure as the testedness measure changes.

38.   In a computerized spreadsheet, a method for providing a user with an indication of how completely tested a spreadsheet cell is, the method comprising:

maintaining a test element for the spreadsheet cell;

calculating a testedness measure of the test element for the spreadsheet cell; and

5   providing the user with an indication of the testedness measure of the test element for the spreadsheet cell.

39.   A method according to claim 38 wherein providing the user with an indication of the testedness measure of the test element for the spreadsheet cell includes providing the

10   user with visual feedback of the testedness measure of the test element for the spreadsheet cell.

40.   A method according to claim 39 wherein providing the user with visual feedback of the testedness measure of the test element for the spreadsheet cell includes

15   coloring an arrow representing the test element for the spreadsheet cell, where the color chosen indicates the testedness measure.

41.   A method according to claim 40 wherein the color chosen to indicate the testedness measure varies between red and blue, the color red representing a 0% testedness

20   percentage and the color blue representing a 100% testedness percentage.

42.   A method according to claim 38 further including updating the indication of the testedness measure as the testedness measure changes.

25   43.   A computer-readable medium containing a testing program to support testing, in a computerized spreadsheet, a spreadsheet cell containing a formula, the testing program comprising:

a test element data structure for storing a set of one or more test elements for the spreadsheet cell;

30   a trace data structure for storing an execution trace of the spreadsheet cell; and

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a subroutine operable to software mark as exercised any test elements that participated in the execution trace.

44.   A testing program according to claim 43 further comprising a subroutine
operable to update the test element data structure as the formula for the spreadsheet cell changes.

45.   A testing program according to claim 43 further comprising a subroutine operable to update the trace data structure as any cell upon which the spreadsheet cell depends changes.

46.   A testing program according to claim 43 further comprising:
a subroutine operable to identify all other spreadsheet cells upon which the spreadsheet cell depends; and
a subroutine operable to update the test element data structure for each other spreadsheet cell.

47.   A testing program according to claim 43 wherein each test element includes:
a definition reference to a definition of a second cell;
a use reference to a use of the definition reference of the second cell in the formula of the spreadsheet cell; and
a du-association between the definition reference and the use reference.

48.   A testing program according to claim 43 further comprising a validation structure that allows a user to mark the spreadsheet cell as validated.

49.   A testing program according to claim 48 wherein the validation structure changes from a checkmark to a question mark when the formula of the spreadsheet cell changes.

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50.   A testing program according to claim 48 wherein the validation structure changes from a checkmark to a blank when the formula of the spreadsheet cell changes.

51.   A system for testing a spreadsheet cell in a spreadsheet on a computer system,
5   the system comprising:

a set of one or more test elements for the spreadsheet cell;

an execution trace of the spreadsheet cell; and

a marking unit to mark as exercised test elements that participated in the execution trace.

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52.   A system according to claim 51 further comprising:

a dependency identification unit to identify all other spreadsheet cells upon which the spreadsheet cell depends; and

a test element update unit to update the test element data structure for each other
15   spreadsheet cell.

53.   A system according to claim 51 wherein each test element includes:

a definition reference to a definition of a second cell;

a use reference to a use of the definition reference of the second cell in the formula of
20   the spreadsheet cell; and

a du-association between the definition reference and the use reference.

54.   A system according to claim 51 further comprising a validation structure that allows a user to mark the spreadsheet cell as validated.

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55.   A system according to claim 54 wherein the validation structure is constructed and arranged to change from a checkmark to a question mark when the formula of the spreadsheet cell changes.

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